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Description

MOBILE PHONE AND RELATED METHOD FOR MATCHING ANTENNA WITH DIFFERENT MATCHING CIRCUITS FOR DIFFERENT BANDS

BACKGROUND OF INVENTION

[0001] 1. Field of the Invention

[0002] The present invention relates to a new antenna architecture used in a mobile phone for adjusting the antenna matching circuits operating in different function modes in different frequency bands. More specifically, a mobile phone having independent matching circuits corresponding to different RF circuits, which is capable of individually adjusting the matching circuits to optimize the mobile phone performance.

[0003] 2. Description of the Prior Art

[0004] Owing to the rapid development of wireless communication systems, people can access resources, exchange in-

formation, and share experiences via a mobile phone or other wireless communication devices anytime and anywhere. Modern mobile phones with dual-band or multi-band capabilities have allowed users to access various wireless network resources and expand access capability for convenience. How to promote the dual-band mobile phones becomes a key point for modern information industry. In a typical multimode, multi-band wireless communication system, the same identical antennaand matching circuit are used to transceive various electromagnetic waves with different frequencies which may have completely differentfield patterns. Therefore, it has become an important issue to efficiently unify various access capabilities associated with various bands into one single antennawhich will not interferethe operation of the antenna in one band with the other. In the following description, we will focus on dual band mobile phones to illustrate the idea. However, the same idea can be applied to any multi-band wireless communication device using a single antenna port to transmit/receive radiation signals.

[0005] Please refer to Fig.1 and Fig.2, where Fig.1 shows a conventional dual-band mobile phone 10 and Fig.2 is a block diagram of the conventional dual-band mobile phone 10.

Mobile phone 10 includes a baseband circuit 18, a radio frequency circuit 40, an antenna 20, an input device 12, a monitor 14, a microphone 36 and a speaker 38. The baseband circuit 18 includes a processor 16 for controlling the operation of the mobile phone 10. The input device 12 can be a button or other trigger devices for receiving control commands from a user and for transmitting them to the processor 16 which controls the mobile phone 10 according to the user"s manipulation. A graphic operation status with respect to the mobile phone 10 can be shown on the monitor 14 through the processor 16. The monitor 14 can be a liquid crystal device (LCD) or a touch panel with the input device 12. The microphone 36 is used to receive sound waves from the user, to generate a corresponding audio signal 42 and to send the audio signal 42 to the baseband circuit 18. The speaker 38 can transform a sound signal 43 into sound waves, and let the user hear the corresponding sound.

[0006] In a dual-band mobile phone, the radio frequency circuit 40 within the mobile phone 10 includes two radio frequency (RF) signal circuits 22A and 22B for accessing different wireless communication networks with different frequency bands. For instance, the radio frequency circuit

signal 22A can be used for processing CDMA (Code Division Multiple Access) signals associated with a PCS (Personal Communication Services) band, where its frequency range is roughly 1900 MHz; the other radio frequency circuit signal 22B can be used for processing AMPS (Advanced Mobile Phone System) signals associated with a Cellular band, where its frequency range is roughly 900 MHz. The RF circuits 22A, 22B respectively include power controllers 28A, 28B, isolators 30A, 30B, duplexers 32A, 32B, and receiving circuits 34A, 34B. Within the conventional mobile phone 10, both the RF circuits 22A, 22B are electrically connected to a matching circuit 26 by way of the diplexer 24, and then are electrically connected to the antenna 20. While one band of the dual-band mobile phone 10 is in use, the RF circuit corresponding to that band is switched on; meanwhile, the other RF circuit operated in the other band within the mobile phone 10 is turned off because the mobile phone 10 temporarily cuts off power supply to it.

[0007] The wireless communication operation of the mobile phone 10 describes as follows. If the band corresponding to the RF circuit 22A is in use, the RF circuit 22B is turned off. Sound from the user is received by the microphone

36, transformed into audio signal 42, and then transmitted to the baseband circuit 18. The baseband circuit 18 encodes, modulates the audio signal 42, and performs other necessary signal processes, so as to generate a communication signal 44A. Then the signal 44A is transmitted to a power controller 28A where it is up converted to the correct frequency and the power level is adjustedto meet the communication requirement. The adjusted communication signal 46A is sent to the duplexer 32A by way of the isolator 30A for ensuring the power from the power controller 28A to the duplexer 32A rather than from the duplexer 32A, where the isolator 30A can greatly reduce the power reflected from the duplexer 32A for preventing from breaking the power controller 28A. The communication signal 46A is transmitted to the matching circuit 26A, and then to the antenna 20, where it is wirelessly broadcasted. In this way, the owner can broadcast desired message to a wireless network through the mobile phone 10. Similarly, messages from the wireless network can be received by the antenna 20 of the mobile phone 10, and then be passed through the matching circuit 26 and the diplexer 24 to the RF circuit 40. The diplexer 24 functions similarly as a filter, capable of filtering of various RF band

signals, and delivering these signals to corresponding RF circuits. For instance, suppose that the RF circuits 22A, 22B are respectively operatedin 1900MHz, 900MHz, after receiving the signal from the antenna 20 by way of the matching circuit 26, the diplexer 24 filters off the signals within 1900MHz and sends them to the RF circuit 22A. Meanwhile, the duplexer 24 filters off the signals within 900MHz and sends them to the RF circuit 22B. A signal received by the RF circuit 22A is passed to the receiving circuit 34A through the duplexer 32A, and then transmitted to the baseband circuit 18 for modulating, decoding, or signal processing so as to generate the corresponding sound signal 43 capable of being transformed into sound waves which can be played by the speaker 38. In this way, the mobile phone 10 can receive messages fromnetwork. Note that the duplexer 32A is similarly functioned as a filter as well. Although the RF circuit 22A is operated under the band of 1900 MHz, the signal emitted from the antenna 20 to the wireless network is substantially in the range of 1850 MHz and 1910 MHz. The signal sent back from the wireless network and received by the antenna 20 is substantially in the range of 1930 MHz and 1990 MHz. Hence, the 1930MHz-to-1990MHz signal can be filtered

off by the duplexer 32A as the received signal 49A and be passed to the receiving circuit 34A.

[0008] Similarly, if the RF circuit 22B is operated under the corresponding band, the RF circuit 22A stops operating. The user"s message will pass the microphone 36, the baseband circuit 18, the RF circuit 22B, the power controller 28B, the isolator 30B, the duplexer 32B, the diplexer 24, the matching circuit 26, and the antenna 20, and is wirelessly sent to the network. The received signal from the wireless network with the corresponding band, received by the antenna 20, will pass the matching circuit 26, the diplexer 24, the duplexer 32B, the receiving circuit 34B, and the baseband circuit 18, and will be played by the microphone 36. Although the RF circuit 22B is operated under the band of 900 MHz, the signal emitted from the antenna 20 to the wireless network is substantially in the range of 824 MHz to 849 MHz. The signal sent back from the wireless network and received by the antenna 20 is substantially in the range of 869 MHz to 894 MHz. Hence, the 869MHz-to-894MHz signal can be filtered off by the duplexer 32B as the received signal 49A and be passed to the receiving circuit 34B.

[0009] For the RF circuit 40 of the conventional mobile phone 10,

in general, the matching circuit 26 is composed of passive components such as resistors, capacitors, and inductors. The phase between voltage and current can be changed and the output power is likely to be reduced whenthe signal is passing through the matching circuit 26. The field pattern of the transmitting signal, especially the near field, emitted from the antenna 20 changes as the phase between the voltage and the current changes. For this reason, the field pattern of the transmitting signal from the antenna 20 changes with the component parameters (e.g. a resistance, a capacitance, an inductance) of the matching circuit 26. From Fig.2 and the above description, no matter which band is in use, the signal has to pass the same matching circuit 26. In other words, the same matching circuit need to be optimized for all frequency bands in use. However, different frequencies may require different matching circuits for optimal performance. This will result in a trouble of the design ofantenna matching circuit. For example, while the RF circuit 22A is operating, the gain of the antenna pattern is probably so large that the power of the wireless signal transmitting from the antenna 20 is too strong. Modifyingthe matching circuit 26 to reduce the antenna gain pattern for RF circuit 22A may

result in a lower or higher than expected gain pattern for RF circuit 22B. Too lower gain may degrade the quality-communication, and too higher gain may lead to a violation of government regulations (eg. FCC regulations). Similarly, for the conventional mobile phone 10, no matter which band is in use, the received or the transmitted signal has to pass the same matching circuit26 andthe antenna gain pattern of the received and transmitted signals may be affected simultaneously.

[0010] Fig.3 shows a block diagram of another conventional mobile phone 50. The mobile phone 50 can be a typical GSM(Global System for Mobile communication)/DCS dual-band mobile phone, which is operated at the GSM900MHz and DCS 1800MHz. For simplicity, the identical labeled components of the mobilephone 50 and those of the mobilephone 10 have the same function. The mobile phone 50 also comprises a microphone 36, a baseband circuit 18, a processor 16, an input device 12, a monitor 14, anantenna 20, and a matching circuit 26. The RF portion 45 comprises two RF circuits, 52A and 52B. Each circuit cantransceiveRF signals in different frequency bands. The two RF circuits also have power controllers 28A, 28B and receiving circuits 34A, 34B. The switch 56 is similar to the

diplexer 24 shown in Fig.2, which is used for transmitting andreceiving signalsfrom the antenna 20 to either the RF circuit 52A or the RF circuit 52B based on the band selected. The switches 54A, 54B within RF circuit 52A, 52B are similar to the duplexers32A, 32B shown in Fig.2. In the case of transmitting signals, sound wavesare transformed into electrical signals by the microphone 36, and then the electrical signal is coded, modulated, and processed by the baseband circuit 18. If operated at the frequency band corresponding to the RF circuit 52B, the processed signal will pass through the power controller 28B, the switch 54B, the switch 56, the matching circuit 26 and then finally be transmitted to the wireless network via the antenna 20. Alternately, in the case ofreceiving signal, the signal received by the antenna 20 will pass through the matching circuit 26, the switch 56, the switch 54B, the receiving circuit 34B, baseband circuit 18 and is finally played by the speaker 38. However, the different transceived signals in different bands have to pass the identical matching circuit 26.Thus the field pattern for each transceived signal can not be individually adjustedand this phone will have the same disadvantage as-the mobile phone 10.

SUMMARY OF INVENTION

[0011] It is therefore a primary objective of the present invention to provide a mobile phone and a related method to solve the problemmentioned above.

[0012] To summarize briefly, the claimed invention provides a mobile phone comprising of independent matching circuits to individually adjust the antenna gain patterns of the transceived signals in different frequency bands. In this way, the mobile phone can be optimized to meet various requirements, which can not only keepgood communication quality, but also reduce unwanted transmitted-electromagnetic power.

[0013] Theseclaimed inventions willbecome obviousafter reading the following detailed description of the invention, which is illustrated invarious figures and drawings.

BRIEF DESCRIPTION OF DRAWINGS

[0014] Fig.1 is a schematic diagram of a conventional dual-band mobile phone according to a prior art.

[0015] Fig.2 is a block diagram of the conventional dual-band mobile phone.

[0016] Fig.3 shows a block diagram of another conventional mobile phone.

[0017] Fig.4 shows a block diagram of a first embodiment of dual-band mobile phone according to the present invention.

[0018] Fig.5 shows a block diagram of a second embodiment of dual-band mobile phone according to the present invention.

[0019] Fig.6 shows a block diagram of a third embodiment of dual-band mobile phone according to the present invention.

DETAILED DESCRIPTION

[0020] Please refer to Fig.4, which shows a block diagram of a first embodiment of dual-band mobile phone 60. The mobile phone 60 can be a CDMA/AMPS/PCS dual-band, tri-mode mobile phone. The mobile phone 60 comprises a baseband circuit 68, an RF circuit 90, an antenna 70, a microphone 86, a speaker 88, an input device 62, and a monitor 64. The baseband circuit 68 has a processor 66 for controlling operation of the mobile phone 60. The user inputs control instruments to the processor 66, which is displayed on the monitor 64 such as an LCD for showing the operation state of the mobile phone 60. The mobile phone 60 has an RF circuit 72A for cellular CDMA/AMPS mode and an RF circuit 72B for PCS mode. Within the RF

circuit 72A, 72B, power controllers 78A, 78B, isolators 80A, 80B, receiving circuits 84A, 84B, a diplexer 74, and duplexers 82A, 82B are identically functioned as the power controllers 28A, 28B, the isolators 30A, 30B, the receiving circuits 34A, 34B, the diplexer 24, and the duplexers 32A, 32B.

[0021] The difference between the present invention and the prior art is that independent matching circuits are individually implemented to adjust the field patterns of the corresponding transceived signals. As shown in Fig.4, within the RF circuits 72A, 72B, the matching circuits 77A, 76A,77B, and 76B are implemented to adjust field patterns of signals in cellular Rx, cellular Tx, PCS Rx, and PCS Tx bands, respectively. For example, when operating under the frequency band corresponding to the RF circuit 72A, the microphone 86 transforms the received sound sent out by the user into audio signal 92. The audio signal 92 is transformed into communication signal 94A through the baseband circuit 68. Meanwhile, the RF circuit 72B is suspended. The power controller 78A will adjust the power of the communication signal 94A into communication signal 96A. The matching circuit 76A adjusts the phase and amplitude of the current and voltage of the

communication signal 96A to generate transmitting signal 98A. Finally, the transmitting signal 98Ais wirelessly sent to a wireless network by the antenna 70through the duplexer 82A and the diplexer 74.

[0022] Alternately, wireless signal from the wireless network is received by the antenna 70 of the mobile phone 60, and is transformed into receiving signal 99A by way of diplexer 74, and duplexer 82A. The matching circuit 77A adjusts the phase and amplitude of the current and voltage of the receiving signal 99A to form receiving signal 99B. The signal 99B through the receiving circuit 84A is processed by the baseband circuit 68 to generate audio signal 93A that is transformed into sound waves and is played by the speaker 88. The amplitude and phase between current and voltage are the key parameters in determining the radiation efficiency as well as the near field radiation pattern. The purpose of the matching circuit is to alter these parameters so as to optimize the antenna performance. In conventional phone designs, this matching circuit is placed between the antenna and the diplexer which can change the current and voltage at the antenna feeding point directly. However, the same purpose can be achieved with different matching circuits placed at differ-

ent locations. As shown in Fig. 4, the matching circuit 76A can be used to adjust the phase and amplitude of the transmitting current and voltage at the antenna port 70 while the matching circuit 77A can be used to adjust the same parameters of the received signal.Because the transmitted and received signals are in different frequency bands, each signal path will have very different signal characteristics. Unlike the conventional design where single matching circuit is used to match the antenna to all frequency bands, in this invention, different matching circuits can be used to optimize the performance of the corresponding band. The same principle is suitable to the RF circuit 72B of the mobile phone 60.

[0023] From above description, the individual matching circuits implemented on different transceiving loops are capable of adjusting the field pattern without interfering with each other. Because the matching circuit 76A is located between the duplexer 82A and the power controller 78A, the equivalent impedance along the receiving loop (i.e. the loop from the duplexer 82A to the receiving circuit 84A) is not changed.Equivalently, the field pattern gain of the receiving loop is also not changed. In this way, on one hand, the field pattern of the transmitting loop is capable of be-

ing properly controlled for reducing the transmitting power of electromagnetic wave, on the other hand, the field pattern of the receiving loop of the antenna 70 remains to ensure the quality of signal-receiving.

[0024] Similarly, the field patterns under various frequency bands are not interfered with each other. As shown in Fig.4, the matching circuits for matching the field pattern are located between the diplexer 74 and the baseband circuit 68. Even if either element parameter of the matching circuits is adjusted, the other matching circuits for the other bands remain the same. For example, if the field pattern of the signal-transmitting through the RF circuit 72B is changed, due to the element parameter adjustment of the matching circuit 76B, both the field pattern of the signal-transceiving through the RF circuit 72A and that of the signal-receiving through the RF circuit 72B are not changed. Therefore, the field patterns associated with various frequency bands are capable of being individually adjusted, improving the prior art defect that each field pattern of signal-transceiving is changed as the element parameter of the matching circuit is altered. Moreover, within the mobile phone 60, the matching circuits 76A, 76B are located between the duplexers 82A, 82B and the

isolators 80A, 80B, where the isolators 80A, 80B are capable of isolating the power from the matching circuit to the power controller. Hence, when the element parameter of the matching circuits 76A, 76B is adjusted, the matching circuit does not cause power reflection to the power controller, which probably will damage the power controller.

[0025] Please refer to Fig.5, which shows a block diagram of a second embodiment of the dual-band mobile phone 100. For simplicity, elements that have the same function as that described in Fig.4 are provided the same item numbers used in the above description of the mobile phone 60. Differing from the mobile phone 60, the mobile phone 100 constitutes the matching circuits 76A, 76B on the signal-transmitting loop, leaving out the matching circuits on the signal-receiving loop. As described above, the different field patterns of the signal-transmitting loops are capable of being respectively adjusted by the matching circuits 76A, 76B. When receiving signal under different frequency bands, the antenna 70 passively receives the radio signal and does not actively transmit electromagnetic waves, not threatening users health. Consequently, it is not necessary to adjust the field pattern of the signal-receiving, and the corresponding matching circuitcan be

omitted. For example, the matching circuit 76A can consist of capacitors C1, C2 and an inductor L1, functioning to adjust the phase and amplitude of the voltage and current. For matching the antenna, the capacitance of the capacitors C1, C2 or the inductance of the inductor L1 are adjusted.

[0026] Please refer to Fig.6, which shows a block diagram of a third embodiment of the mobile phone 110. Similar to the mobile phone 50 shown in Fig.3, the mobile phone 110 can be a GSM/DCS dual-band mobile phone. For simplicity, elements that have the same function as that described in Fig.5 are provided the same item numbers used in the above description of the mobile phone 100. The RF circuit 134 of the mobile phone 110 has two RF circuits 122A and 122B corresponding to two frequency bands. The two RF circuits have switches 124A, 124B, power controllers 108A, 108B, receiving circuits 114A, 114B, functioning as the switches 54A, 54B, the power controllers 28A, 28B, and receiving circuits 34A, 34B shown in Fig.3, respectively. A switch 126 functions as the switch 56 shown in Fig.3 for distributing signal from the antenna 70 to the two RF circuits 122A, 122B. Comparing with Figs. 3 and 6, individual matching circuits 116A, 116B and 117A,

117B are constituted so as to independently adjust the field pattern of signal-transceiving, without interfering with each other.

[0027] In contrast to prior art, the present invention mobile phone has independent matching circuits corresponding to different RF circuits, and is capable of individually adjusting the field pattern of the transceived signal of the mobile phone. When adjusting either matching circuit, only the field pattern of transceived signal corresponding to the adjusted matching circuit is changed, but the transceived signal corresponding to the other matching circuits remains the same. Consequently, the designer is capable of adjusting optimal field pattern depending on different transceived signal requirements, which are operated on different frequency bands. So, the mobile phone can not only keep good quality for received signal, but also adjust the transmitted electromagnetic power to the probable level at the same time. According to the present invention, the technique is employed to the single-band mobile phone as well, for adjusting the field pattern of signal-transmitting and that of signalreceiving for the same frequency band. Furthermore, the present invention technique is also capable of being applied to other wire-

less apparatuses, which also belongs to the scope of the present invention.

[0028] Those skilled in the art will readily observe that numerous modifications and alterations of the method and the device may be made while retaining the technique of the invention. Accordingly, the above disclosure should be construed as limited only by the metes and bounds of the appended claims.